

Figure IV-3-6. Plot of mean flow velocity against mean grain size, based on laboratory studies, showing stability phases of subaqueous bed forms (modified from Ashley (1990)). Original data from various sources, standardized to 10° C water temperature (original data points not shown)

b. General delta classification. Coleman and Wright (1975) identified six broad classes of deltas using an energy criteria. These models have been plotted on Figure IV-3-7 according to the relative importance of river, wave, and tide processes. However, Wright (1985) acknowledged that because each delta has unique and distinct features, no classification scheme can adequately encompass the wide variety of environments and structures found at deltas around the world.

c. Delta-forming processes.

(1) Force balance. Every delta is the result of a balance of forces that interact in the vicinity of the river mouth. A river carries sediment to the coast and deposits it beyond the mouth. Tidal currents and waves rework the newly deposited sediments, affecting the shape and form of the resulting structure. The long-term evolution of a delta plain becomes a function of the rate of riverine sediment input and the rate and pattern of sediment reworking, transport, and deposition by marine processes after the initial deposition. On a large scale, gross deltaic shape is also influenced by receiving basin geometry, regional tectonic stability, rates of subsidence caused by compaction of newly deposited sediment, and rate of sea level rise.

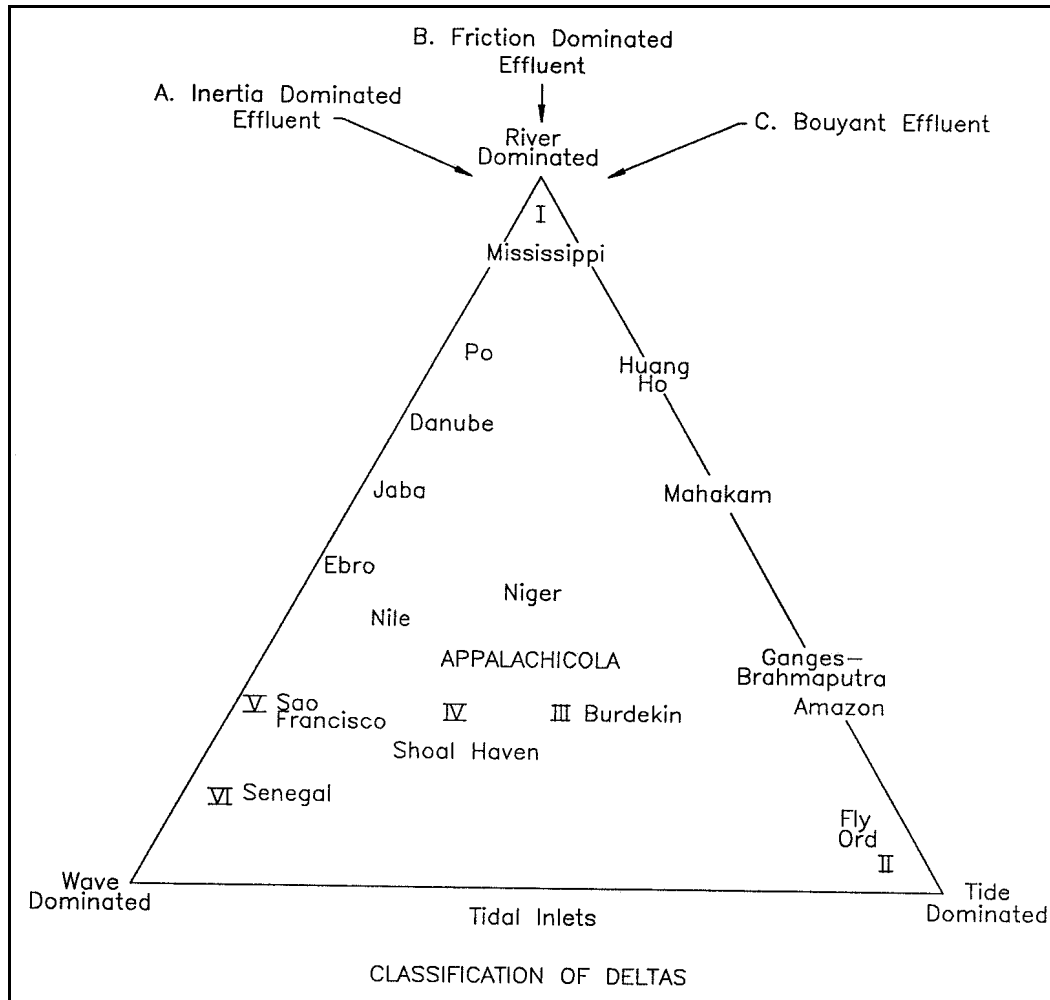


Figure IV-3-7. Classification of deltas

(2) River-dominant deltas.

(a) River-dominant deltas are found where rivers carry so much sediment to the coast that the deposition rate overwhelms the rate of reworking and removal due to local marine forces. In regions where wave energy is very low, even low-sediment-load rivers can form substantial deltas.

(b) When a river is completely dominant over marine forces, the delta shape develops as a pattern of prograding, branching distributary channels (resembling fingers branching from a hand). Interdistributary features include open bays and marshes. A generalized isopach map for this type of delta (Type I in Coleman and Wright's (1975) classification) is shown in Figure IV-3-8. A prime example is the Mississippi River, which not only transports an enormous amount of sediment, but also empties into the low wave-energy, low tide-range Gulf of Mexico (Figure IV-3-9). The Fraser River, which flows into the sheltered Strait of Georgia, is another example (Figure IV-3-10). The Mississippi is discussed in more detail later.

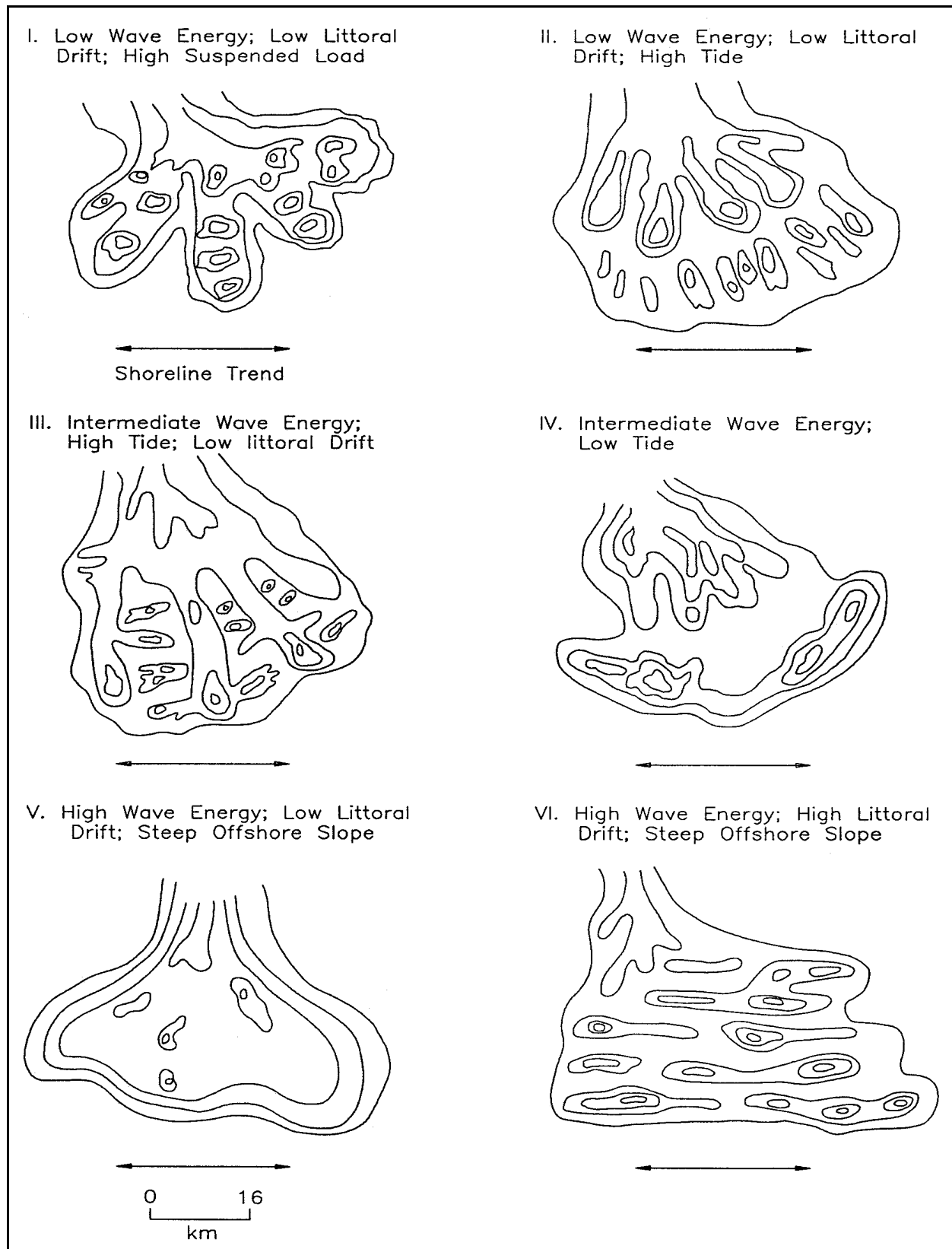


Figure IV-3-8. Isopach map for river-dominant deltas

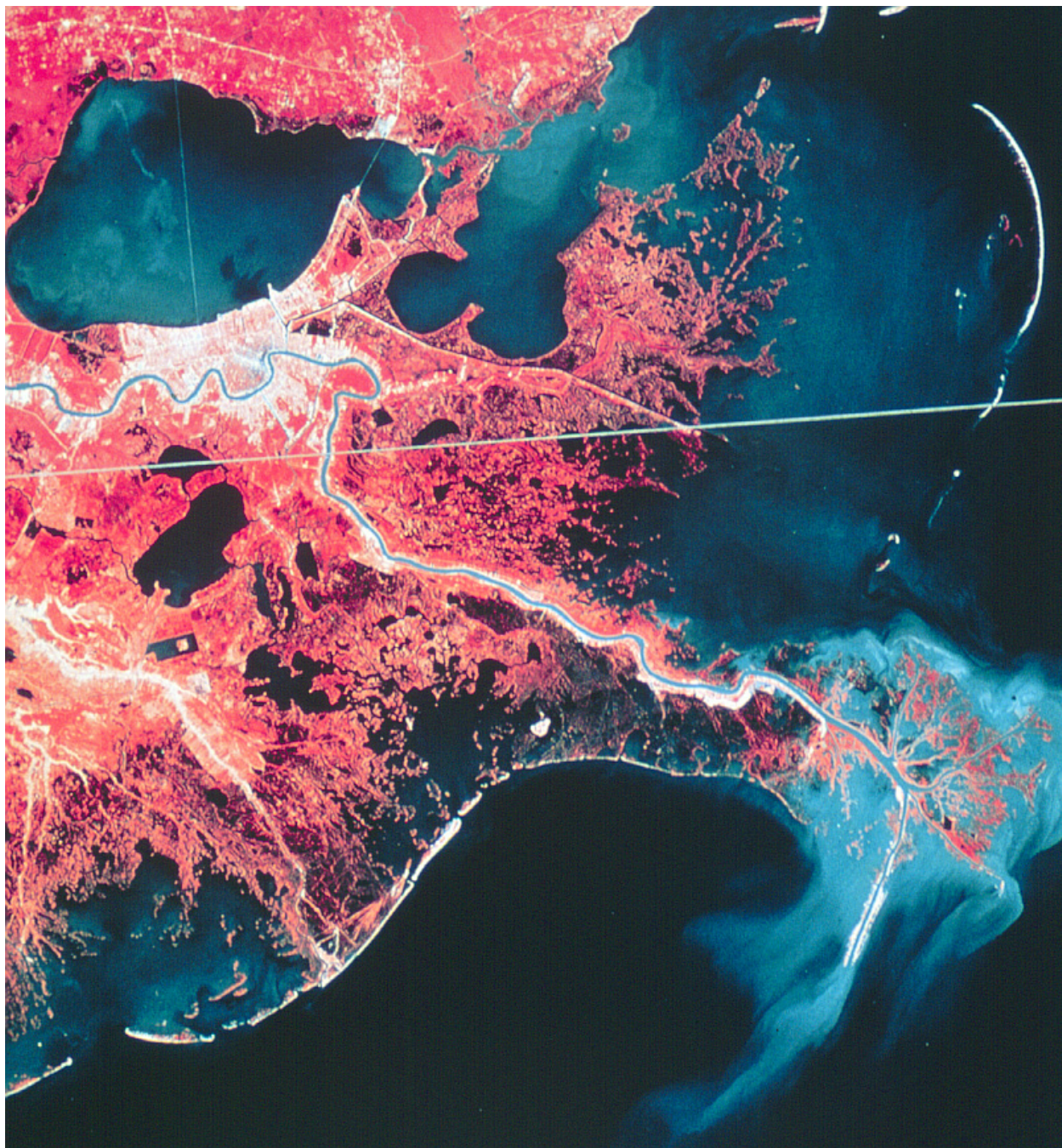


Figure IV-3-9. Mississippi River Delta. The river, which flows into the Gulf of Mexico, has several outlets that are dredged by the Corps of Engineers almost continuously. The city of New Orleans is at the upper left of the image immediately south of Lake Pontchartrain. Landsat 2 image (date unknown)

(3) Wave-dominant deltas.

(a) At wave-dominant deltas, waves sort and redistribute sediments delivered to the coast by rivers and remold them into shoreline features such as beaches, barriers, and spits. The morphology of the resulting delta reflects the balance between sediment supply and the rate of wave reworking and redistribution. Wright and Coleman (1972, 1973) found that deltas in regions of the highest nearshore wave energy flux developed

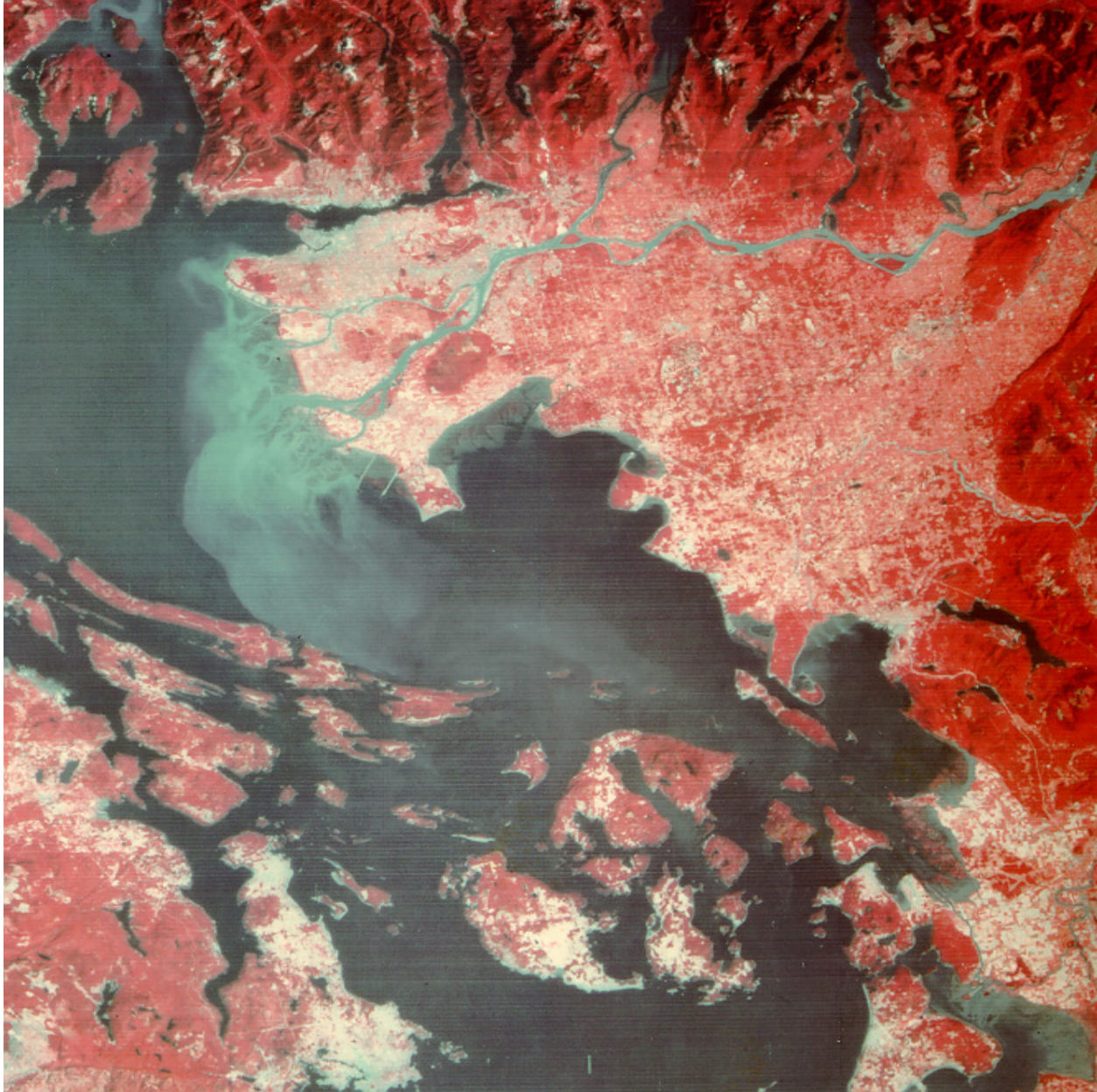


Figure IV-3-10. Fraser River Delta, British Columbia. The river flows into the sheltered Strait of Georgia past the city of Vancouver. The strait has high tidal currents, as shown by the plume of turbid water flowing to the southeast. This delta is also Class I, riverine-dominated (NASA ERTS, 12 Aug 1973)

the straightest shorelines and best-developed interdistributary beaches and beach-ridge complexes (Figure IV-2-3).

(b) Of 16 deltas compared by Wright and Coleman (1972, 1973), the Mississippi was the most river-dominated while the Senegal in west Africa was the other extreme, the most wave-dominated. A model of the Senegal (Type VI in Figure IV-3-8) shows that abundant beach ridges are parallel to the prevailing shoreline trend and that the shore is relatively straight as a result of high wave energy and a strong unidirectional littoral drift.

(c) An intermediate delta form is represented by the delta of the Rio São Francisco del Norte in Brazil (Type V in Figure IV-3-8). Distributary-mouth-bar deposits are restricted to the immediate vicinity of the river mouth and are quickly remolded by waves. Persistent wave energy redistributes the riverine sediment to form extensive sand sheets. The exposed delta plain consists primarily of beach ridges and aeolian dunes.

(4) Tide-dominant deltas.

Three important processes characterize tide-dominated deltas:

(a) At the river mouths, mixing obliterates vertical density stratification, eliminating the effects of buoyancy.

(b) For part of the year, tidal currents may be responsible for a greater fraction of the sediment-transporting energy than the river. As a result, sediment transport in and near the river mouth is bidirectional over a tidal cycle.

(c) The location of the land-sea interface and the zone of marine-riverine interactions is greatly extended both vertically and horizontally. Examples of deltas that are strongly influenced by tides include the Ord (Australia), Shatt-al-Arab (Iraq), Amazon (Brazil), Ganges-Brahmaputra (Bangladesh), and the Yangtze (China). Characteristic features of river mouths in macrotidal environments are bell-shaped, sand-filled channels and linear tidal sand ridges. The crests of the ridges, which have relief of 10-20 m, may be exposed at low tide. The ridges replace the distributary-mouth bars found at other deltas and become the dominant sediment-accumulation form. As the delta progrades over time, the ridges grow until they are permanently exposed, forming large, straight tidal channels (Type II in Figure IV-3-8). An example of a macrotidal delta is the Ord of Western Australia and the Essex River Delta in Massachusetts (Figure IV-3-11).

(5) Intermediate forms.

(a) As stated above, the morphology of most deltas is a result of a combination of riverine, tidal, and wave forces. One example of an intermediate form is the Burdekin Delta of Australia (Type II in Figure IV-3-8). High waves redistribute sands parallel to the coastline trend and remold them into beach ridges and barriers. Within the river mouths, tidal currents produce sand-filled river channels and tidal creeks. This type of delta displays a broad range of characteristics, depending upon the relative strength of waves versus tides. In addition, features may vary seasonally if runoff and wave climate change. Other examples include the Irrawaddy (Burma), Mekong (Vietnam), and Red (Vietnam) Deltas (Wright 1985).

(b) The fourth model of delta geometry is characterized by offshore bay-mouth barriers that shelter lagoons, bays, or estuaries into which low-energy deltas prograde (Type IV, Figure IV-3-8). Examples include the Apalachicola (Florida Panhandle), Sagavanirktok (Alaska), and Shoalhaven (southeastern Australia) Deltas (Wright 1985). In contrast to the river-dominant models, the major accumulation of prodelta mud occurs landward of the main sand body (the barrier), and at the same elevation, within the protected bay. Although suspended fines reach the open sea, wave action prevents mud accumulation as a distinct unit over the open shelf.

d. Deltaic components and sediments.

(1) Generally, all deltas consist of four physiographic zones: an alluvial valley, upper deltaic plain, lower deltaic plain, and subaqueous deltaic plain (Figure IV-3-12). The deposition that occurs adjacent to and between the distributary channels accounts for most of the subaerial delta. In the case of the Mississippi